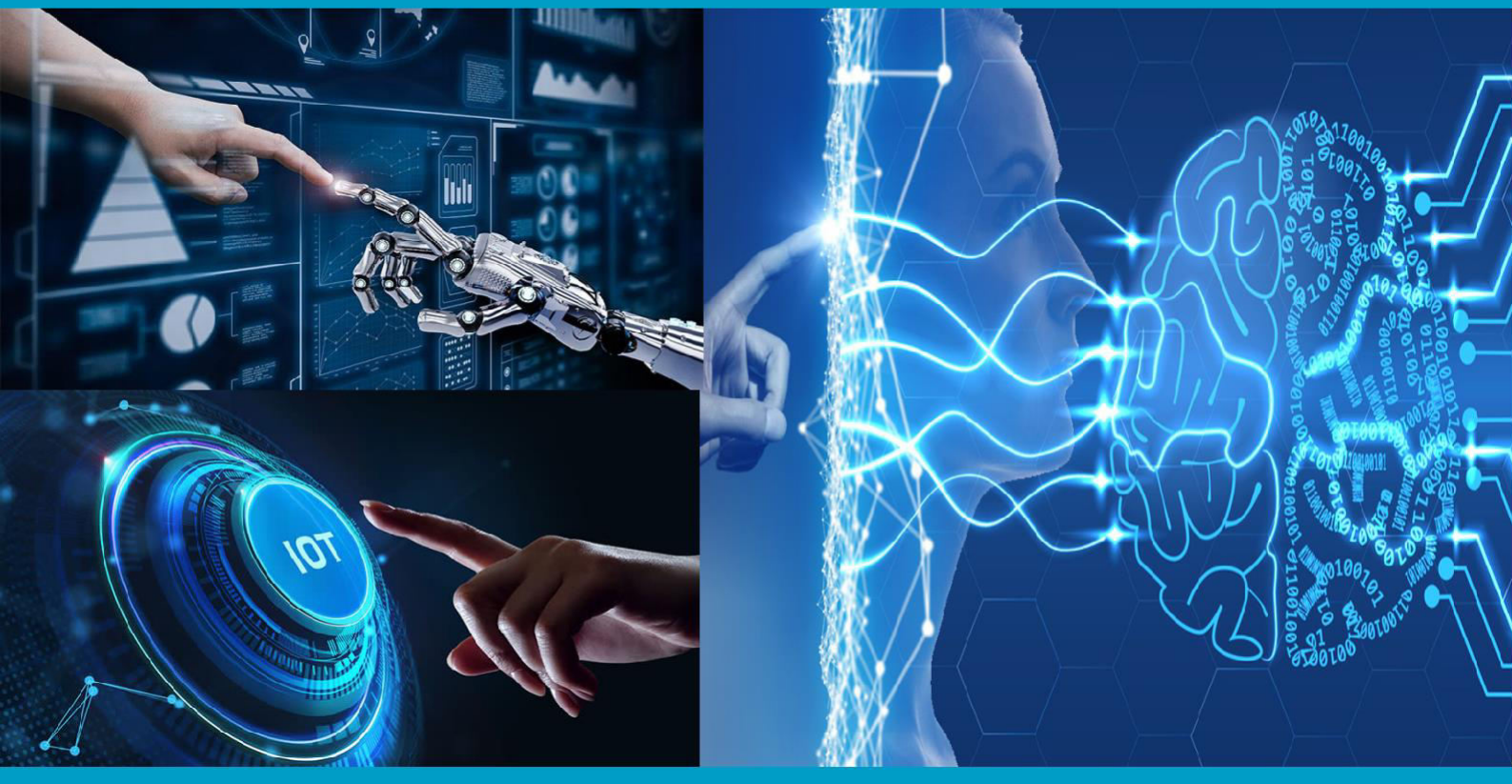
IJMRSETM

e-ISSN: 2395 - 7639



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

Volume 12, Issue 5, May 2025

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.214

International Journal of Multidisciplinary Research in Science, Engineering, Technology & Management (IJMRSETM)

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 8.214 | A Monthly Double-Blind Peer Reviewed Journal |

| Volume 12, Issue 5, May 2025 |

Automatic Chemical mixing Process using PLC for Pharmaceutical Industry

Prof. Ms. Tejal Bandgar[1], Mr. Shreyash Shinde[2], Mr. Shravankumar Maske[3], Mr. Aditya Lakesar[4]

Ms. Ankita Zende[5]

Assistant Professor Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology, Ashta Maharashtra, India[1]

UG Student, Department of Electrical Engineering, Annasaheb Dange College of Engineering and Technology, Ashta Maharashtra, India[2345]

ABSTRACT: This project presents the design and implementation of an automatic chemical mixing system using a Programmable Logic Controller (PLC) for the pharmaceutical industry. The system operates in both manual and automatic modes, allowing flexible control over the mixing process. A Human-Machine Interface (HMI) is integrated to enable real-time monitoring and user-defined adjustments of operational parameters such as mixing time and direction. The setup includes a 24V 10A SMPS for stable power supply, DC gear motors for controlled mixing, and pumps for fluid transfer. An automatic cleaning mode ensures hygiene and prevents cross-contamination between batches. The project aims to enhance process efficiency, accuracy, and safety while reducing manual intervention, aligning with Industry 4.0 standards for smart manufacturing.

KEYWORDS: Programmable Logic Controller (PLC), Human-Machine Interface (HMI), Automatic Chemical Mixing, Pharmaceutical Industry, DC Gear Motor, SMPS Power Supply, Ladder Logic, Dual Operation Modes, Cleaning Cycle, Industrial Automation.

I. INTRODUCTION

In modern pharmaceutical manufacturing, precision and hygiene are critical in achieving high-quality products. One essential process is chemical mixing, where specific chemicals are blended under controlled conditions to ensure consistency and safety. Traditionally, this task involved manual intervention, which increased the risks of human error, contamination, and variability in product quality.

To address these challenges, this project introduces an automatic chemical mixing system using a Programmable Logic Controller (PLC). The system is designed with dual operational modes—manual and automatic—to offer both flexibility and efficiency. In manual mode, operators can directly control motor direction and duration using push buttons. In automatic mode, the system follows a pre-programmed sequence involving forward and reverse mixing actions with specified delays, enhancing material uniformity and reducing processing time.

The project also includes an automated cleaning process using distilled water, ensuring that the mixing chamber and connected pipelines are free from residual chemicals after each batch. This not only maintains hygiene standards but also minimizes downtime and supports continuous operations.

An HMI screen is integrated to provide real-time monitoring and allow users to adjust process parameters such as mixing duration and mode selection without altering the PLC code. The combination of PLC control, HMI interface, and modular design makes the system a reliable, scalable, and energy-efficient solution suited for pharmaceutical, chemical, and food industries.

This project demonstrates how automation can enhance process control, reduce human dependency, and ensure regulatory compliance in industrial mixing systems.

II. RELATED WORK

Over the years, researchers have explored numerous automation strategies in industrial mixing to improve process accuracy, reduce human intervention, and ensure product quality. Ugwuoke [1] developed a PLC-based industrial mixer with a 50-liter batch capacity, improving homogeneity and reducing operational errors through automation.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 8.214 | A Monthly Double-Blind Peer Reviewed Journal |

| Volume 12, Issue 5, May 2025 |

Rahman et al. [2] highlighted the role of PLCs integrated with sensors in waste management systems, emphasizing real-time monitoring and cost-effectiveness, which is applicable to cleaning processes in chemical industries. Gadhe et al. [3] implemented a ladder logic-based control system for syrup and color mixing, reducing human error and improving consistency in product output. Sreejith and Chouhan [4] designed an automated dual-liquid mixing and bottling system, showing enhanced efficiency through accurate proportioning and automatic filling. Kurkute et al. [5] presented a PLC and SCADA-based mixing and bottle-filling prototype aimed at beverage industries, with real-time visualization and ratio-based precision. Kayalvizhi and Abilash [6] emphasized sensor-based automation using PLCs to minimize manual labor and enhance output accuracy in fluid mixing. Brown and Wilson [7] discussed advancements in PLC systems for industrial mixers, highlighting improvements in sensor integration, fault detection, and real-time control that reduce downtime and increase productivity. Muralidharan et al. [8] proposed an automatic fluid filling mechanism using Delta PLC, focusing on industrial-scale liquid handling with improved reliability. Kim and Park [9] explored PLC automation for industrial mixers, showcasing improved mixing efficiency through real-time control algorithms. Nguyen and Lee [10] developed smart control strategies for PLC-driven mixing systems, enhancing fault tolerance and control precision for complex mixing operations. Miller and Davis [11] demonstrated scalable PLC-based mixing architectures tailored to industrial automation needs, validating their approach through field testing. Sharma and Patel [12] introduced logic enhancements in ladder programming to improve cleaning cycles and reduce power consumption in automated mixing setups.

III. METHODOLOGY

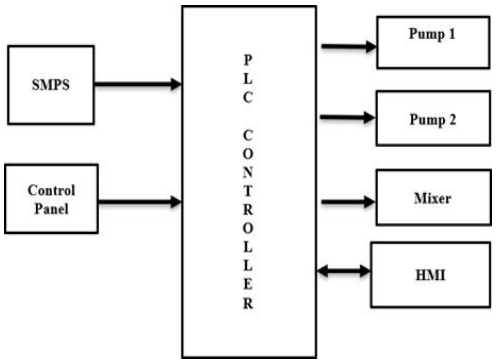


Fig.1 System Block Diagram

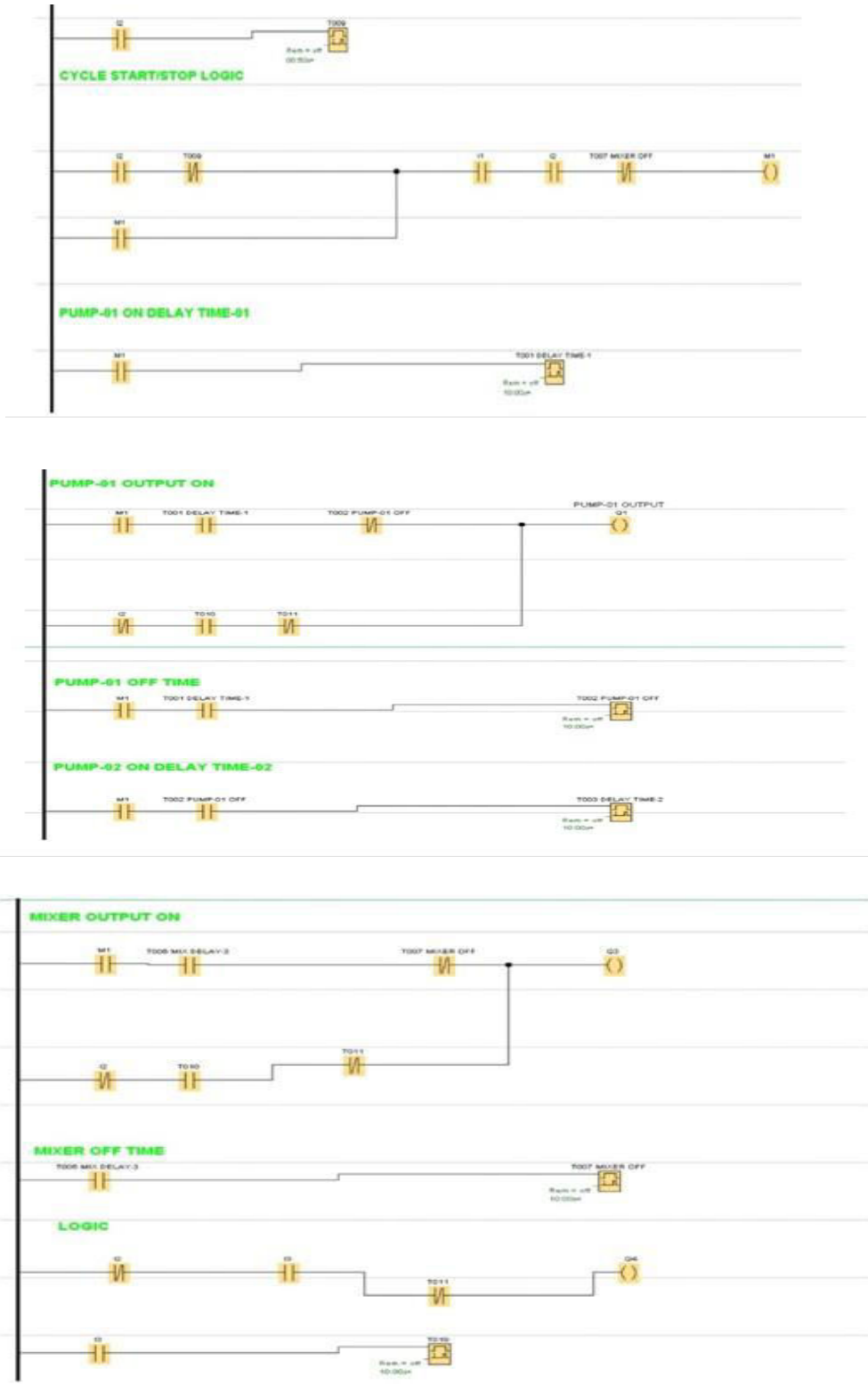
In order to automate the chemical mixing process for pharmaceutical applications, the system in Fig. 1 incorporates several essential components. A stable 24V DC supply from an SMPS powers the entire setup, ensuring consistent energy delivery to the PLC, sensors, relays, and actuators. The Siemens LOGO! PLC acts as the brain of the system, executing ladder logic instructions to control pump activation, motor direction, and timing sequences. Input signals from mode selection buttons and optional sensors are processed by the PLC, which then outputs control signals to the pumps and DC gear motor. The HMI interface allows operators to monitor system status and adjust set times for mixing and cleaning operations in real time. The feedback mechanism, in the form of HMI readouts and potentially integrated level or flow sensors, ensures operational reliability by allowing dynamic adjustment without needing to modify the PLC program. By synchronizing the PLC logic, HMI control, and hardware components, the system ensures high accuracy, hygiene, and process flexibility. With future integration of IoT and AI technologies, the system can support predictive maintenance, remote monitoring, and intelligent control, further enhancing productivity, safety, and industrial adaptability.

| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 8.214 | A Monthly Double-Blind Peer Reviewed Journal |

| Volume 12, Issue 5, May 2025 |

IV. EXPERIMENTAL RESULTS

a. Ladder Diagram:



| ISSN: 2395-7639 | www.ijmrsetm.com | Impact Factor: 8.214 | A Monthly Double-Blind Peer Reviewed Journal |

| Volume 12, Issue 5, May 2025 |

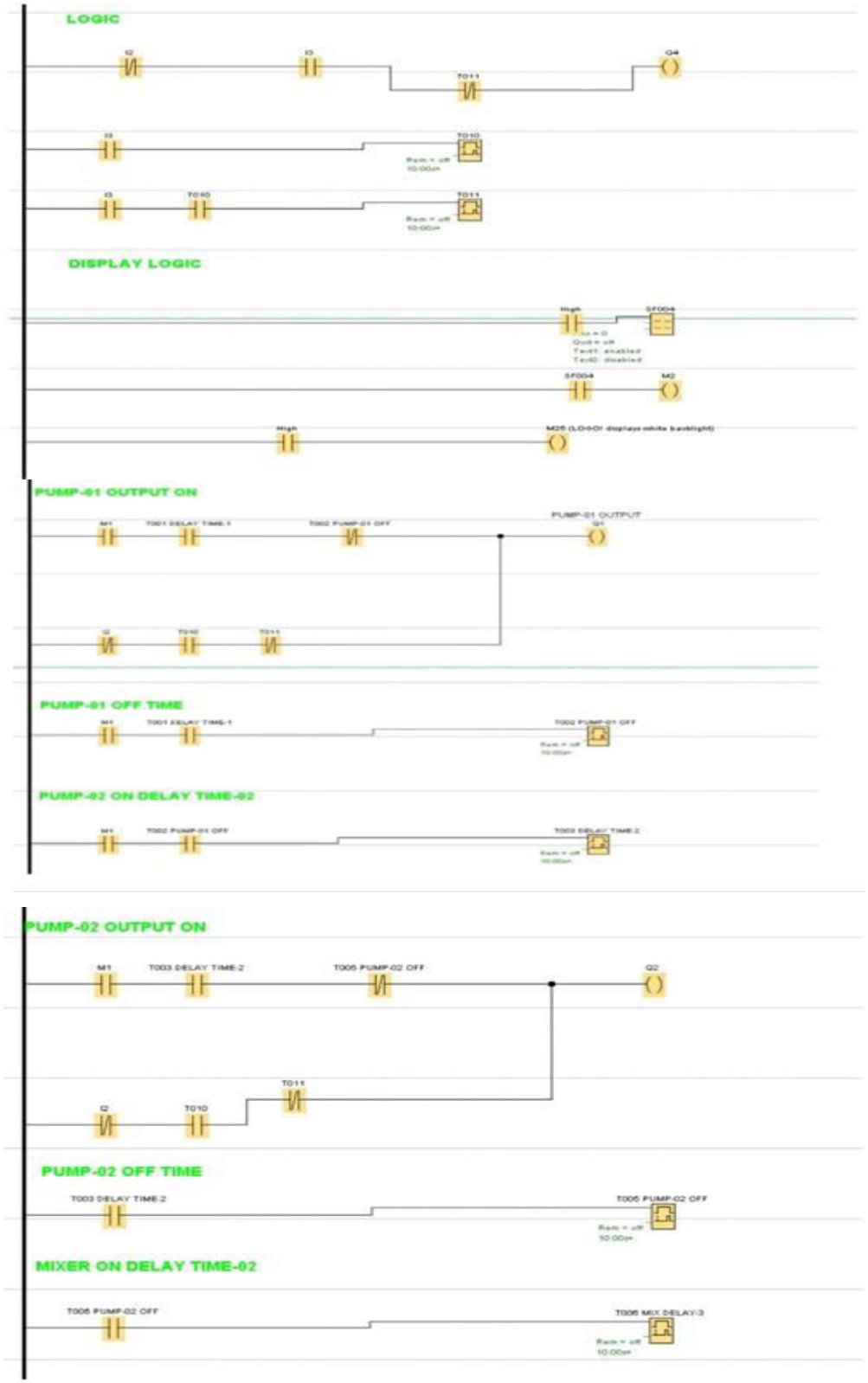


Fig.2 Simulation Ladder Logic

Fig.3 Hardware systemResults:

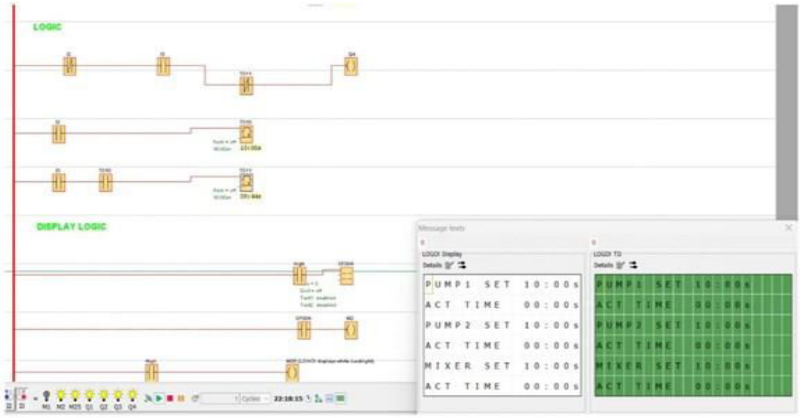


Fig.4 Process Analysis

Fig. 4 shows the ladder logic simulation and corresponding HMI output for the automatic chemical mixing process. In the automatic mode, the PLC successfully executed the programmed sequence: Pump 1 and Pump 2 operated with defined delays, followed by the activation of the DC gear motor for a set duration, achieving uniform and consistent mixing. The cleaning mode, when triggered, operated all components simultaneously to ensure effective system flushing with distilled water.The HMI interface displayed both the actual operation time and user-defined set time, confirming accurate execution of logic without the need for manual reprogramming. Real-time adjustments were successfully made via the HMI, verifying the flexibility of the system.

The implemented system demonstrated reliable performance under varying time intervals and modes. Compared to traditional manual mixing setups, the PLC-based system reduced human intervention, minimized mixing inconsistencies, and improved hygiene through automated cleaning. The result confirms the effectiveness of using PLC and HMI for precision-controlled, efficient, and scalable chemical mixing operations in industrial applications.

V. CONCLUSION

The integration of Programmable Logic Controllers (PLCs) in industrial mixers marks a significant step forward in enhancing the efficiency, precision, and flexibility of mixing operations across various industries. By automating critical processes such as chemical mixing and cleaning, PLC-based systems address key challenges like human error, contamination, and inconsistency, particularly in industries like pharmaceuticals where precision and hygiene are paramount.

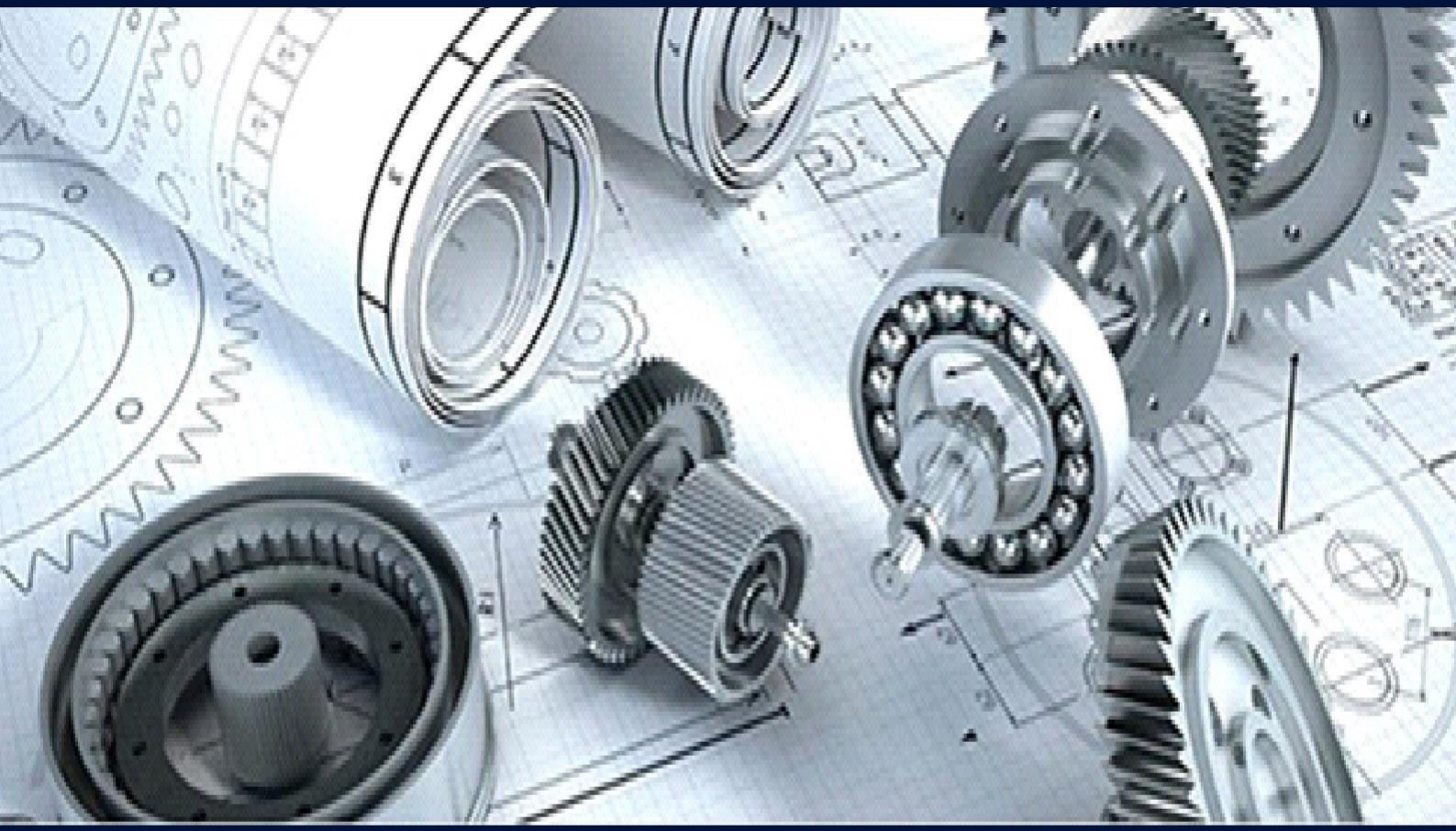
This project highlights the transformative impact of PLCs, offering dual operational modes—manual and automatic—to cater to diverse production requirements. The automatic mode ensures consistent and optimized mixing through predefined sequences, while the manual mode allows operators to tailor operations to specific needs. Additionally, the

inclusion of an automated cleaning process not only simplifies maintenance but also guarantees compliance with stringent hygiene standards, ensuring that the equipment remains contaminated-free between batches.

By prioritizing automation, sustainability, and adaptability, this PLC-based industrial mixer demonstrates its potential to enhance productivity, maintain product quality, and meet evolving industry demands. It stands as a testament to the value of integrating advanced control systems in modern manufacturing processes, setting a benchmark for future innovations in chemical mixing and industrial automation.

REFERENCES

1. Ugwuoke, I. (2023). Development of a 50-Liter Batch Capacity Industrial Mixer with PLC Automation. International Journal of Engineering Applications (IJEA), 15(3), 370-382.
2. Rahman, M. A., Banna, H. A., Hossain, A., Khan, M. M. H., Patwary, S. H. I., Mallik, T., & Islam,
3. M. N. (2021). Effectiveness of PLC-Based Systems in Waste Management: Integration of Sensors for Real-Time Monitoring and Control. Journal of Environmental Engineering and Management, 18(2), 123-135.
4. Gadhe, A., Bhojane, P., & Kawade, K. (2018). Enhancing Productivity and Consistency Through PLC-Based Automation: A Focus on Medicinal Syrup, Color Mixing, and Food Production. International Journal of Industrial Automation and Control, 14(4), 220-233.
5. Sreejith, M., & Chouhan, S. (2016). Automation of Liquid Mixing and Bottling Processes: Enhancing Productivity and Quality with Reduced Manual Intervention. Journal of Automation and Process Control, 11(2), 145-158.
6. Prof. Swapnil R. Kurkute, Mr. Akshay S. Kulkarni, Mr. Mahesh V. Gare, Mr. Soham S. Mundada (2016). A Prototype of an Automated Liquid Mixing and Bottle Filling System Using PLC and SCADA for Control and Visualization. Journal of Engineering and Technology, 5(4), 12-20.
7. P. Kayalvizhi, D. Ajay Abilash (2016). Automated Filling and Mixing Systems Utilizing Sensors and PLCs for Enhanced Efficiency. International Journal of Industrial Automation, 4(2), 67-74.
8. Ugwuoke, I. (2023). Development of a 50-Liter Batch Capacity Industrial Mixer with PLC Automation. International Journal of Engineering Applications (IJEA), 15(3), 370-382.
9. Rahman, M. A., Banna, H. A., Hossain, A., Khan, M. M. H., Patwary, S. H. I., Mallik, T., & Islam,
10. M. N. (2021). Effectiveness of PLC-Based Systems in Waste Management: Integration of Sensors for Real-Time Monitoring and Control. Journal of Environmental Engineering and Management, 18(2), 123-135.
11. Gadhe, A., Bhojane, P., & Kawade, K. (2018). Enhancing Productivity and Consistency Through PLC-Based Automation: A Focus on Medicinal Syrup, Color Mixing, and Food Production. International Journal of Industrial Automation and Control, 14(4), 220-233.
12. Sreejith, M., & Chouhan, S. (2016). Automation of Liquid Mixing and Bottling Processes: Enhancing Productivity and Quality with Reduced Manual Intervention. Journal of Automation and Process Control, 11(2), 145-158.



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING, TECHNOLOGY AND MANAGEMENT

+91 99405 72462 +91 63819 07438 ijmrsetm@gmail.com